First Hit Fwd Refs Previous Doc Next Doc Go to Doc#

End of Result Set

☐ Generate Collection Print

L1: Entry 1 of 1 File: USPT Mar 4, 2003

US-PAT-NO: 6528959
DOCUMENT-IDENTIFIER: US 6528959 B2

TITLE: Driving force control system for front-and-rear wheel drive vehicles

DATE-ISSUED: March 4, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Kitano; Kazuhiko	Saitama-ken			JP
Fukuda; Toshihiko	Saitama-ken			JP
Yonekura; Takahiro	Saitama-ken			JP
Uchiyama; Naoki	Saitama-ken			JP
Honda; Kenji	Saitama-ken			JP
Nakasako; Tooru	Saitama-ken			JP

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Honda Giken Kogyo Kabushiki Kaisha	Tokyo			JP	03

APPL-NO: 09/906054 [PALM]
DATE FILED: July 17, 2001

FOREIGN-APPL-PRIORITY-DATA:

COUNTRY	APPL-NO	APPL-DATE
JP	2000-219408	July 19, 2000
JP	2000-232890	August 1, 2000
JP	2000-234090	August 2, 2000

INT-CL-ISSUED: [07] H02P 7/66

INT-CL-CURRENT:

TYPE	IPC	DATE
CIPS	B60 K 6/04	20060101
CIPS	B60 K 6/00	20060101
CIPS	B60 K 28/16	20060101
CIPS	B60 T 8/1769	20060101
CIPS	B60 T 8/17	20060101
CIPS	B60 T 8/48	20060101

US-CL-ISSUED: 318/55; 318/52, 318/58, 318/64, 180/65.1

US-CL-CURRENT: 318/55; 180/65.1, 318/52, 318/58, 318/64, 903/916, 903/926, 903/940, 903/941, 903/942

FIELD-OF-CLASSIFICATION-SEARCH: 318/52, 318/55, 318/58, 318/64, 180/65.1
See application file for complete search history.

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected | Search ALL | Clear

	PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
☐	5540299	July 1996	Tohda et al.	180/242
☐	5788005	August 1998	Arai	180/247
☐	5927425	July 1999	Kusano	180/248
☐	6205379	March 2001	Morisawa et al.	180/165
☐	6349782	February 2002	Sekiya et al.	180/197

ART-UNIT: 2837

PRIMARY-EXAMINER: Leykin; Rita

ATTY-AGENT-FIRM: Arent Fox Kintner Plotkin & Kahn, PLLC

ABSTRACT:

There is provided a driving force control system for a front-and-rear wheel drive vehicle, which is capable maintaining an optimum slip condition of the drive wheels even on a low-friction road surface, ensuring a proper grip of rear wheels even on a low-friction road surface or a downhill slope, even when the driver operates the steering wheel while the vehicle is performing decelerating travel on such a road, and smoothly performing the assistance of an electric motor when the vehicle is accelerated without developing a torque step, thereby ensuring stable traveling and excellent acceleration and drivability. The front-and-rear wheel drive vehicle drives the front wheels by an engine, and rear wheels by an electric motor via an electromagnetic clutch. The target driving force for driving the vehicle is calculated based on at least a vehicle speed and an accelerator pedal opening. The present traveling condition of the vehicle is determined. The driving force for driving the vehicle is controlled based on the calculated target driving force in dependence on the determined traveling condition of the vehicle.

11 Claims, 37 Drawing figures

Previous Doc Next Doc Go to Doc#

suddenly drops by an extent equal to the large driving force of the electric motor. In this case, it is difficult to synchronize the generation of the driving force of the electric motor and the drop of the driving force of the engine, so that occurrence of a certain amount of torque step is inevitable. Particularly, when the vehicle is accelerated from a low-speed traveling condition, or from a decelerating condition, the total driving force is largely increased even when the accelerator pedal is stepped on by a small amount, and therefore, the above-mentioned problem tend to be conspicuous.

Brief Summary Text (18):
Particularly to attain the first object, it is preferred that the driving force demand degree-detecting means comprises accelerator opening-detecting means for detecting an accelerator opening, the traveling condition-determining means including differential rotational speed-detecting means for detecting a differential rotational speed between a rotational speed of the front drive wheels and a rotational speed of the rear drive wheels based on a parameter indicative of the traveling condition of the vehicle, target differential rotational speed-setting means for setting a target differential rotational speed based on the parameter indicative of the traveling condition of the vehicle, and slip determination means for determining a slip condition of the one pair driven by the engine, based on the detected differential rotational speed and the target differential rotational speed, the driving force control means including target motor driving force-calculating means for calculating a target motor driving force of the electric motor based on the target driving force, target engine driving force-calculating means for calculating a target engine driving force of the engine based on the target driving force and the target motor driving force, motor drive control means for controlling driving of the electric motor based on the target motor driving force, engine drive control means for controlling driving of the engine based on the target engine driving force, and engine driving force-correcting means for decreasing the target engine driving force such that the differential rotational speed is held at the target differential rotational speed, when it is determined by the slip determination means that the one pair driven by the engine are slipping.

Brief Summary Text (41):
As described above, if the vehicle is accelerated by stepping on the accelerator pedal when the vehicle is in a decelerating condition in which the accelerator pedal is released, the driving of the electric motor is permitted irrespective of the speed ratio of the torque converter. In this case, the assistance of the electric motor can be started immediately after the start of the acceleration without being affected by the delay in a change in the speed ratio, and the motor driving force can be progressively increased starting with a small value. Therefore, the assistance of the electric motor can be smoothly performed without developing a torque step caused by the delay in a change in the speed ratio of the torque converter.

CLAIMS:

2. A driving force control system according to claim 1, wherein said driving force demand degree-detecting means comprises accelerator opening-detecting means for detecting an accelerator opening, wherein said traveling condition-determining means includes differential rotational speed-detecting means for detecting a differential rotational speed between a rotational speed of the front drive wheels and a rotational speed of the rear drive wheels based on a parameter indicative of the traveling condition of the vehicle, target differential rotational speed-setting means for setting a target differential rotational speed based on the parameter indicative of the traveling condition of the vehicle, and slip determination means for determining a slip condition of the one pair driven by the engine, based on the detected differential rotational speed and the target differential rotational speed, and wherein said driving force control means

includes target motor driving force-calculating means for calculating a target motor driving force of the electric motor based on the target driving force, target engine driving force-calculating means for calculating a target engine driving force of the engine based on the target driving force and the target motor driving force, motor drive control means for controlling driving of the electric motor based on the target motor driving force, engine drive control means for controlling driving of the engine based on the target engine driving force, and engine driving force-correcting means for decreasing the target engine driving force such that the differential rotational speed is held at the target differential rotational speed, when it is determined by said slip determination means that the one pair driven by the engine are slipping.

Previous Doc Next Doc Go to Doc#

L2: Entry 1 of 1 File: USPT Mar 4, 2003

DOCUMENT-IDENTIFIER: US 6528959 B2
TITLE: Driving force control system for front-and-rear wheel drive vehicles

Brief Summary Text (9):
Further, the present assignee has already proposed another driving force control system of the above-mentioned type e.g. by Japanese Patent Application No. 11-366934. A front-and-rear wheel drive vehicles incorporating this control system has its front wheels driven by an engine via a torque converter, and its rear wheels driven by an electric motor. In this driving force control system, the driving conditions for driving the rear wheels by the electric motor, i.e. the conditions for executing the four-wheel drive include one determined based on a speed ratio of the torque converter. More specifically, the control system is configured such that if the detected speed ratio of the torque converter is equal to or larger than a predetermined value, the electric motor is stopped to execute the two-wheel drive, whereas if the former is lower than the latter, the electric motor is operated to execute the four-wheel drive. For instance, when the vehicle is started, the speed ratio tends to be small and hence the torque amplification factor of the torque converter is high, which makes the vehicle more prone to slippage. Therefore, the control system causes the electric motor to be operated to drive the rear wheels to assist the driving of the vehicle by the rear wheels, thereby improving the startability of the vehicle. Further, when the vehicle is being accelerated by the driver stepping on the accelerator pedal, the sliding of the torque converter increases, so that the speed ratio of the same temporarily drops. In such a case as well, the assistance of driving of the vehicle by the rear wheels is carried out to thereby ensure excellent acceleration of the vehicle. It should be noted that in the four-wheel drive state, first, the total driving force required for driving the vehicle is determined, and the driving force of the electric motor is determined such that the maximum output therefrom is an upper limit value thereof, and the driving force of the engine is determined as a difference obtained by subtracting the driving force of the electric motor from the total driving force.

Brief Summary Text (10):
In this driving force control system, however, there is room for improvement, because a torque step can be produced during acceleration for the following reason: In this driving force control system, as described above, when the vehicle is accelerated, a decrease in the speed ratio of the torque converter is expected which is caused by sliding of the torque converter, and the assistance of the electric motor is started on condition that the speed ratio becomes lower than the predetermined value. However, the sliding of the torque converter does not occur instantly, but progressively increases, so that there is a time lag before the speed ratio actually decreases below the predetermined value, i.e. before the assistance of the electric motor is started. On the other hand, the total driving force continues to be increased in response to the demand for acceleration, and since the driving force of the electric motor remains set to 0, the driving force of the engine continues to be increased at the same ratio. As a result, when the speed ratio becomes lower than the predetermined value, a large driving force of the electric motor is suddenly generated, and the driving force of the engine suddenly drops by an extent equal to the large driving force of the electric motor.

In this case, it is difficult to synchronize the generation of the driving force of the electric motor and the drop of the driving force of the engine, so that occurrence of a certain amount of torque step is inevitable. Particularly, when the vehicle is accelerated from a low-speed traveling condition, or from a decelerating condition, the total driving force is largely increased even when the accelerator pedal is stepped on by a small amount, and therefore, the above-mentioned problem tend to be conspicuous.

Brief Summary Text (18):
Particularly to attain the first object, it is preferred that the driving force demand degree-detecting means comprises accelerator opening-detecting means for detecting an accelerator opening, the traveling condition-determining means including differential rotational speed-detecting means for detecting a differential rotational speed between a rotational speed of the front drive wheels and a rotational speed of the rear drive wheels based on a parameter indicative of the traveling condition of the vehicle, target differential rotational speed-setting means for setting a target differential rotational speed based on the parameter indicative of the traveling condition of the vehicle, and slip determination means for determining a slip condition of the one pair driven by the engine, based on the detected differential rotational speed and the target differential rotational speed, the driving force control means including target motor driving force-calculating means for calculating a target motor driving force of the electric motor based on the target driving force, target engine driving force-calculating means for calculating a target engine driving force of the engine based on the target driving force and the target motor driving force, motor drive control means for controlling driving of the electric motor based on the target motor driving force, engine drive control means for controlling driving of the engine based on the target engine driving force, and engine driving force-correcting means for decreasing the target engine driving force such that the differential rotational speed is held at the target differential rotational speed, when it is determined by the slip determination means that the one pair driven by the engine are slipping.

Brief Summary Text (41):
As described above, if the vehicle is accelerated by stepping on the accelerator pedal when the vehicle is in a decelerating condition in which the accelerator pedal is released, the driving of the electric motor is permitted irrespective of the speed ratio of the torque converter. In this case, the assistance of the electric motor can be started immediately after the start of the acceleration without being affected by the delay in a change in the speed ratio, and the motor driving force can be progressively increased starting with a small value. Therefore, the assistance of the electric motor can be smoothly performed without developing a torque step caused by the delay in a change in the speed ratio of the torque converter.

CLAIMS:

2. A driving force control system according to claim 1, wherein said driving force demand degree-detecting means comprises accelerator opening-detecting means for detecting an accelerator opening, wherein said traveling condition-determining means includes differential rotational speed-detecting means for detecting a differential rotational speed between a rotational speed of the front drive wheels and a rotational speed of the rear drive wheels based on a parameter indicative of the traveling condition of the vehicle, target differential rotational speed-setting means for setting a target differential rotational speed based on the parameter indicative of the traveling condition of the vehicle, and slip determination means for determining a slip condition of the one pair driven by the engine, based on the detected differential rotational speed and the target differential rotational speed, and wherein said driving force control means includes target motor driving force-calculating means for calculating a target

motor driving force of the electric motor based on the target driving force, target engine driving force-calculating means for calculating a target engine driving force of the engine based on the target driving force and the target motor driving force, motor drive control means for controlling driving of the electric motor based on the target motor driving force, engine drive control means for controlling driving of the engine based on the target engine driving force, and engine driving force-correcting means for decreasing the target engine driving force such that the differential rotational speed is held at the target differential rotational speed, when it is determined by said slip determination means that the one pair driven by the engine are slipping.

Previous Doc Next Doc Go to Doc#

L3: Entry 1 of 1 File: USPT Mar 4, 2003

DOCUMENT-IDENTIFIER: US 6528959 B2
TITLE: Driving force control system for front-and-rear wheel drive vehicles

Abstract Text (1):
There is provided a driving force control system for a front-and-rear wheel drive vehicle, which is capable maintaining an optimum slip condition of the drive wheels even on a low-friction road surface, ensuring a proper grip of rear wheels even on a low-friction road surface or a downhill slope, even when the driver operates the steering wheel while the vehicle is performing decelerating travel on such a road, and smoothly performing the assistance of an electric motor when the vehicle is accelerated without developing a torque step, thereby ensuring stable traveling and excellent acceleration and drivability. The front-and-rear wheel drive vehicle drives the front wheels by an engine, and rear wheels by an electric motor via an electromagnetic clutch. The target driving force for driving the vehicle is calculated based on at least a vehicle speed and an accelerator pedal opening. The present traveling condition of the vehicle is determined. The driving force for driving the vehicle is controlled based on the calculated target driving force in dependence on the determined traveling condition of the vehicle.

Brief Summary Text (6):
The conventional driving force control system, however, simply inhibits the operation of the electric motor to thereby completely stop the assistance thereof, when it is determined during the slip control of the front wheels that the vehicle can move forward. Therefore, the total driving force for driving the vehicle tends to become short, and the slip of the front wheels is liable to be increased. Further, the determination as to whether the vehicle can move forward or not is carried out only by estimation based on the vehicle speed detected then, and therefore, depending on a subsequent operation of the accelerator pedal and the like, the slip of the front wheels can become excessively large, so that the front wheels cannot be maintained in an optimum slip condition, which makes it impossible to perverse traveling stability of the vehicle on a low-friction road surface.

Brief Summary Text (7):
Another driving force control system of the above-mentioned type was also proposed which causes the engine braking force to act on the front wheels and the braking torque caused by the electric motor to act on the rear wheels during a decelerating travel condition in which the accelerator pedal is released, to thereby brake the vehicle (e.g. Japanese Laid-Open Patent Publication No. 9-298802). In this case, the braking by the electric motor is carried out by producing a resisting force or drag force against the rotation of the rear wheels, during the decelerating travel of the vehicle.

Brief Summary Text (9):
Further, the present assignee has already proposed another driving force control system of the above-mentioned type e.g. by Japanese Patent Application No. 11-366934. A front-and-rear wheel drive vehicles incorporating this control system has its front wheels driven by an engine via a torque converter, and its rear wheels driven by an electric motor. In this driving force control system, the driving

conditions for driving the rear wheels by the electric motor, i.e. the conditions for executing the four-wheel drive include one determined based on a speed ratio of the torque converter. More specifically, the control system is configured such that if the detected speed ratio of the torque converter is equal to or larger than a predetermined value, the electric motor is stopped to execute the two-wheel drive, whereas if the former is lower than the latter, the electric motor is operated to execute the four-wheel drive. For instance, when the vehicle is started, the speed ratio tends to be small and hence the torque amplification factor of the torque converter is high, which makes the vehicle more prone to slippage. Therefore, the control system causes the electric motor to be operated to drive the rear wheels to assist the driving of the vehicle by the rear wheels, thereby improving the startability of the vehicle. Further, when the vehicle is being accelerated by the driver stepping on the accelerator pedal, the sliding of the torque converter increases, so that the speed ratio of the same temporarily drops. In such a case as well, the assistance of driving of the vehicle by the rear wheels is carried out to thereby ensure excellent acceleration of the vehicle. It should be noted that in the four-wheel drive state, first, the total driving force required for driving the vehicle is determined, and the driving force of the electric motor is determined such that the maximum output therefrom is an upper limit value thereof, and the driving force of the engine is determined as a difference obtained by subtracting the driving force of the electric motor from the total driving force.

Brief Summary Text (10):
In this driving force control system, however, there is room for improvement, because a torque step can be produced during acceleration for the following reason: In this driving force control system, as described above, when the vehicle is accelerated, a decrease in the speed ratio of the torque converter is expected which is caused by sliding of the torque converter, and the assistance of the electric motor is started on condition that the speed ratio becomes lower than the predetermined value. However, the sliding of the torque converter does not occur instantly, but progressively increases, so that there is a time lag before the speed ratio actually decreases below the predetermined value, i.e. before the assistance of the electric motor is started. On the other hand, the total driving force continues to be increased in response to the demand for acceleration, and since the driving force of the electric motor remains set to 0, the driving force of the engine continues to be increased at the same ratio. As a result, when the speed ratio becomes lower than the predetermined value, a large driving force of the electric motor is suddenly generated, and the driving force of the engine suddenly drops by an extent equal to the large driving force of the electric motor. In this case, it is difficult to synchronize the generation of the driving force of the electric motor and the drop of the driving force of the engine, so that occurrence of a certain amount of torque step is inevitable. Particularly, when the vehicle is accelerated from a low-speed traveling condition, or from a decelerating condition, the total driving force is largely increased even when the accelerator pedal is stepped on by a small amount, and therefore, the above-mentioned problem tend to be conspicuous.

Brief Summary Text (27):
Particularly to attain the second object, it is preferred that the vehicle includes an accelerator pedal, and a steering wheel, the driving force demand degree-detecting means including accelerator condition-detecting means for detecting whether or not the accelerator pedal is in a released condition, the traveling condition-determining means including downhill traveling-determining means for determining whether or not the vehicle is traveling downhill, and steering angle-detecting means for detecting an steering angle of the steering wheel, the driving force control means including target deceleration-setting means for setting a target deceleration based on the detected steering angle when the accelerator condition-detecting means detects that the accelerator pedal is in the released condition and at the same time the downhill traveling-determining means determines that the vehicle is traveling downhill, engine braking force-calculating means for

calculating an engine braking force according to the detected vehicle speed when the accelerator condition-detecting means detects that the accelerator pedal is in the released condition, target braking force-setting means for setting a target braking force of the electric motor for braking the rear wheels, based on the set target deceleration and the calculated engine braking force, and drive control means for controlling driving of the electric motor based on the set target driving force.

Brief Summary Text (28):
According to this preferred embodiment, when the released condition of the accelerator pedal is detected and at the same time it is determined that the front-and-rear drive vehicle is traveling downhill, the target deceleration is set based on the detected steering angle, and when the released condition of the accelerator pedal is detected, the engine braking force is calculated based on the detected vehicle speed. Then, based on the set target deceleration and the calculated engine braking force, the target braking force of the electric motor for braking the vehicle is set. In this case, since the target braking force of the electric motor is set based on the target deceleration and the engine braking force, as the target deceleration, i.e. the deceleration of the whole vehicle is larger, the target braking force of the electric motor is set to a larger value. Then, based on the set target braking force, the driving of the electric motor is controlled. This makes it possible to set the target deceleration to an appropriate value responsive to the steering angle of the vehicle traveling downhill. Therefore, when the steering angle is turned through a larger steering angle, the target deceleration, i.e. the deceleration of the whole vehicle can be set to a smaller value, to thereby reduce the braking force applied to the rear wheels and accordingly prevent the biased distribution of the axle load toward the front wheel side. As a result of the reduced braking force applied to the rear wheels, and the prevention of the biased distribution of the axle load toward the front wheel side, it is possible to enhance the lateral grip of the rear wheels on the road surface and thereby positively control a skid of the vehicle even when the lateral force acts on the rear wheels through turning of the steering wheel during downhill traveling of the vehicle on a low-friction road surface. As a result, it is possible to ensure a stable traveling of the vehicle.

Brief Summary Text (33):
Particularly to attain the second object, it is preferred that the vehicle include an accelerator pedal and a steering wheel, the driving force demand degree-detecting means including accelerator condition-detecting means for detecting whether or not the accelerator pedal is in a released condition, the traveling condition-determining means including steering angle-detecting means for detecting a steering angle of the steering wheel, the driving force control means including engine braking force-calculating means for calculating an engine braking force of the engine according to the detected vehicle speed when the accelerator condition-detecting means detects that the accelerator pedal is in the released condition, target braking force-setting means for setting a target braking force of the electric motor for braking the rear wheels to a value corresponding to the calculated engine braking force, target braking force-correcting means for correcting the set target braking force according to the detected steering angle, and drive control means for controlling driving of the electric motor based on the corrected target braking force.

Brief Summary Text (34):
In general, when the front-and-rear wheel drive vehicle is braked, the braking force of the front wheels and that of the rear wheels are set to respective values equal to each other, whereby the behavior of the vehicle becomes hard to get out of order but stable. Therefore, according to the preferred embodiment, when the released condition of the accelerator pedal is detected, the engine braking force is calculated according to the detected vehicle speed, and the target braking force of the electric motor is set to a value equal to the calculated engine braking

force, whereby the behavior of the vehicle in decelerating travel by release of the accelerator pedal can be stabilized. Further, since the target braking force is corrected according to the detected steering angle, the target deceleration can be set to an appropriate value reflecting the steering angle of the vehicle assumed during the decelerating travel. This enables the braking force of the electric motor to be made smaller as the steering wheel is turned through a larger steering angle, whereby through the reduction of the braking force applied to the rear wheels and the prevention of the biased distribution of the axle load toward the front wheel side, the lateral grip of the rear wheels on the road surface can be enhanced. As a result, even when the vehicle is performing decelerating travel on a low-friction road surface, for instance, it is possible to positively suppress a skid of the rear wheels caused by the operation of the steering wheel. (It should be noted that "values equal to each other" is used to mean not only values quite identical to each other but also values in a substantially equal range.)

Brief Summary Text (39):
Also, particularly to attain the third object, it is preferred that the vehicle includes a torque converter, and is driven while switching between a four-wheel drive mode in which the one pair are driven by the engine via the torque converter and at the same time the another pair are driven by the electric motor and a two-wheel drive mode in which the driving of the another pair by the electric motor is inhibited, the driving force demand degree-detecting means including an accelerator opening-detecting means for detecting an accelerator opening, the traveling condition-determining means including speed ratio-detecting means for detecting a speed ratio of the torque converter, reference speed ratio-storing means for storing a predetermined reference speed ratio, speed ratio-determining means for determining whether or not the detected speed ratio is larger than the predetermined reference speed ratio, and stepping operation-detecting means for detecting whether or not the accelerator pedal in the released condition is stepped on, during the traveling of the vehicle, the driving force control means including target motor driving force-calculating means for calculating a target motor driving force of the electric motor, motor drive means for driving the electric motor based on the calculated target motor driving force, and motor drive-permitting means for permitting the driving of the electric motor by the motor drive means when the stepping operation-detecting means detects that the accelerator pedal is stepped on, and when the stepping operation-detecting means does not detect that the accelerator pedal is stepped on, inhibits the driving of the electric motor on condition that the speed ratio-determining means determines that the detected speed ratio is smaller than the predetermined reference speed ratio.

Brief Summary Text (40):
According to this preferred embodiment, when it is detected whether or not the accelerator pedal in the released state is stepped during traveling of the vehicle. If such an operation of stepping on the accelerator pedal is detected, the driving of the electric motor is permitted, whereas if not, the driving of the electric motor is inhibited on condition that the speed ratio of the torque converter is larger than the predetermined reference speed ratio.

Brief Summary Text (41):
As described above, if the vehicle is accelerated by stepping on the accelerator pedal when the vehicle is in a decelerating condition in which the accelerator pedal is released, the driving of the electric motor is permitted irrespective of the speed ratio of the torque converter. In this case, the assistance of the electric motor can be started immediately after the start of the acceleration without being affected by the delay in a change in the speed ratio, and the motor driving force can be progressively increased starting with a small value. Therefore, the assistance of the electric motor can be smoothly performed without developing a torque step caused by the delay in a change in the speed ratio of the torque converter.

Detailed Description Text (9):
Further, the ECU 11 receives a signal indicative of a sensed degree of opening (accelerator pedal opening) .theta.AP including ON/OFF (stepped-on/released) states of the accelerator pedal 17 from an accelerator pedal opening sensor 16, and a signal indicative of a remaining charge SOC stored in the battery 7 from a charge amount sensor 18. Still further, the ECU 11 is supplied with a signal indicative of a sensed braking pressure PBR from a braking pressure sensor 19 mounted to a master cylinder of a brake 30, a signal indicative of a sensed steering angle .theta.STR of a steering wheel 31 from a steering angle sensor 20, a signal indicative of a sensed shift lever position POSI of the automatic transmission 5 from a shift position sensor 21, and signals indicative of sensed accelerations GF, GR of the respective front and rear wheels WF, WR from acceleration sensors 22, 23.

Detailed Description Text (12):
Then, at a step S22, the present control mode of the vehicle 2 is determined based on the shift lever position POSI of the automatic transmission 5, the ON/OFF state of the accelerator pedal (hereinafter referred to as "the AP") 17, and the traveling condition of the vehicle 2, which were detected at the step S21. More specifically, if the vehicle 2 is in the forward traveling condition or in the reverse traveling condition with the AP 17 in its ON state, it is determined that the control mode is a forward drive mode or a reverse drive mode (these two modes are hereinafter generically referred to as "the drive mode"), whereas if the vehicle 2 is in the forward traveling condition or in the reverse traveling condition with the AP 17 in its OFF state, it is determined that the control mode is a forward decelerating regeneration mode or a reverse decelerating regeneration mode (these two modes are hereinafter generically referred to as "the decelerating regeneration mode"). Further, if the vehicle 2 is in stoppage, the control mode is determined as a stoppage mode. When the control mode is the decelerating regeneration mode, basically, the battery 7 is charged by utilizing the regenerative braking torque.

Detailed Description Text (21):
At the following step S33, the target rear-wheel driving force FCMD_MOT is calculated. This calculation is performed in a manner dependent on the control mode (according to one of the drive mode, the decelerating regeneration mode, the cruising recharge mode, and the stoppage mode) determined at the step S22 in FIG. 2 and the above step S32. For instance, when the vehicle is started, the target rear-wheel driving force FCMD_MOT for the drive mode (in which the driving force is assisted by the motor) is calculated as follows: First, the distribution of the driving force between the front pair and the rear pair of wheels is calculated based on the distribution of the whole vehicle weight during the stoppage of the vehicle (e.g. 57% of the whole vehicle weight on the front wheels, and 43% of the same on the rear wheels) and the slope angle (SLOPE_ANG). The slope angle SLOPE_ANG is calculated, on condition that the rotational speeds N_FL, N_FR of the front wheels and the rotational speeds N_RL, N_RR of the rear wheels are all equal to 0, and at the same time the brake pedal is being operated, by integrating the outputs from the front and rear acceleration sensors 22, 23, by using the following equation (1):

Detailed Description Text (61):
First, at a step S130, it is determined whether or not an accelerator OFF flag F_APOFF assumes 1. The accelerator OFF flag F_APOFF is set, based on the signal from the accelerator opening sensor 16, to 1 when the accelerator pedal 17 is OFF, i.e. in a released state, and to 0 when the same is stepped on.

Detailed Description Text (77):
On the other hand, if the answer to the question of the step S130 is negative (NO), i.e. if the accelerator pedal is being stepped on, it is judged that the vehicle 2 is not traveling downhill, so that the program proceeds to a step S147, wherein the target deceleration DIC_G is set to the natural deceleration DIC_G_CD, and at the

same time, the downhill traveling flag F_RGNS1 is set to 0.

Detailed Description Text (161):
In contrast, in the case of the present embodiment illustrated in FIG. 35A, if the vehicle 2 is accelerated from the low-speed condition thereof, the amount of change in the target driving force dFCMD becomes equal to or larger than the predetermined value dFCMD_AST so that the answer to the question of the step S365 in FIG. 30 becomes affirmative (YES), or if the vehicle 2 is accelerated from the decelerating condition in which the accelerator pedal 1 in the OFF state, the control mode is shifted from the decelerating regeneration mode to the drive mode, whereby the answer to the question of the step S362 becomes affirmative (YES), whereby in both of the above cases, the assistance is permitted irrespective of the speed ratio ETR (step S366). This makes it possible to start the assistance of the motor 4 immediately after the time t1 the acceleration of the vehicle 2 is started. As a result, the assistance of the motor 4 can be started from the state of the target motor driving force FCMD_MOT being still small, and continued by progressively increasing the same, and at the same time, the engine driving force FCMD_ENG is progressively decreased, whereby the assistance of the motor 4 can be started smoothly without developing a torque step. It should be noted that in FIGS. 35A, 35B, FCMD_MOT_F represents a value of the target rear-wheel driving force after being filtered by the step S34 in FIG. 3.

Detailed Description Text (168):
At the step S390 et seq., the limiting process for limiting the target rear-wheel driving force FCMD_MOT is carried out by taking the distribution factor of the weight of the vehicle 2 into account. First, at the step S390, a weight shift amount dWt is calculated by dividing the product of the vehicle weight (FR_DYN_WT+RR_DYN_WT), a road slope angle SLOPE_ANG, and the height Hight_Wt of the center of gravity of the vehicle 2 multiplied by each other, by the wheel base Wheel_base. In this calculation, FR_DYN_WT, RR_DYN_WT represent a weight on the front wheel side, and a weight on the rear wheel side, respectively. Further, the road surface slope SLOPE_ANG represents a value thereof determined when the vehicle 2 is in stoppage, which is estimated by calculation through integrating the outputs from the front and rear acceleration sensors 22, 23 when the front-wheel rotational speeds N_FL, N_FR and the rear-wheel rotational speeds N_RL, N_RR are all equal to 0, and at the same time, the brake pedal is being operated.

Detailed Description Text (171):
As described above, according to the present embodiment, if the vehicle 2 is accelerated from the low-speed condition thereof, the amount of change in the target driving force dFCMD becomes equal to or larger than the predetermined value dFCMD_AST or if the vehicle 2 is accelerated from the decelerating condition in which the accelerator pedal is in the OFF state, the control mode is shifted from the decelerating regeneration mode to the drive mode, whereby in both of the above cases, the assistance of the motor 4 is permitted irrespective of the speed ratio ETR of the torque converter. This makes it possible to start the assistance of the motor 4 immediately after the acceleration of the vehicle 2 is started. As a result, the assistance of the motor 4 can be started from the state of the target motor driving force FCMD_MOT being still small, and continued by progressively increasing the same, whereby the assistance of the motor 4 can be started smoothly without developing a torque step. This makes it possible to secure the excellent acceleration and drivability.

CLAIMS:

6. A driving force control system according to claim 1, wherein the vehicle includes an accelerator pedal, and a steering wheel, wherein said driving force demand degree-detecting means includes accelerator condition-detecting means for detecting whether or not the accelerator pedal is in a released condition, wherein said traveling condition-determining means includes downhill traveling-determining

means for determining whether or not the vehicle is traveling downhill, and steering angle-detecting means for detecting an steering angle of the steering wheel, and wherein said driving force control means includes target deceleration-setting means for setting a target deceleration based on the detected steering angle when said accelerator condition-detecting means detects that the accelerator pedal is in the released condition and at the same time said downhill traveling-determining means determines that the vehicle is traveling downhill, engine braking force-calculating means for calculating an engine braking force according to the detected vehicle speed when said accelerator condition-detecting means detects that the accelerator pedal is in the released condition, target braking force-setting means for setting a target braking force of the electric motor for braking the rear wheels, based on the set target deceleration and the calculated engine braking force, and drive control means for controlling driving of the electric motor based on the set target driving force.

9. A driving force control system according to claim 1, wherein the vehicle include an accelerator pedal and a steering wheel, wherein said driving force demand degree-detecting means includes accelerator condition-detecting means for detecting whether or not the accelerator pedal is in a released condition, wherein said traveling condition-determining means includes steering angle-detecting means for detecting a steering angle of the steering wheel, and wherein said driving force control means includes engine braking force-calculating means for calculating an engine braking force of the engine according to the detected vehicle speed when said accelerator condition-detecting means detects that the accelerator pedal is in the released condition, target braking force-setting means for setting a target braking force of the electric motor for braking the rear wheels to a value corresponding to the calculated engine braking force, target braking force-correcting means for correcting the set target braking force according to the detected steering angle, and drive control means for controlling driving of the electric motor based on the corrected target braking force.

11. A driving force control system according to claim 1, wherein the vehicle includes a torque converter, and is driven while switching between a four-wheel drive mode in which the one pair are driven by the engine via the torque converter and at the same time the another pair are driven by the electric motor and a two-wheel drive mode in which the driving of the another pair by the electric motor is inhibited, wherein said driving force demand degree-detecting means includes an accelerator opening-detecting means for detecting an accelerator opening, wherein said traveling condition-determining means includes speed ratio-detecting means for detecting a speed ratio of the torque converter, reference speed ratio-storing means for storing a predetermined reference speed ratio, speed ratio-determining means for determining whether or not the detected speed ratio is larger than the predetermined reference speed ratio, and stepping operation-detecting means for detecting whether or not the accelerator pedal in the released condition is stepped on, during the traveling of the vehicle, and wherein said driving force control means includes target motor driving force-calculating means for calculating a target motor driving force of the electric motor, motor drive means for driving the electric motor based on the calculated target motor driving force, and motor drive-permitting means for permitting the driving of the electric motor by said motor drive means when said stepping operation-detecting means detects that the accelerator pedal is stepped on, and when said stepping operation-detecting means does not detect that the accelerator pedal is stepped on, inhibits the driving of the electric motor on condition that the speed ratio-determining means determines that the detected speed ratio is smaller than the predetermined reference speed ratio.

L6: Entry 1 of 1 File: USPT Mar 4, 2003

DOCUMENT-IDENTIFIER: US 6528959 B2
TITLE: Driving force control system for front-and-rear wheel drive vehicles

Detailed Description Text (33):
Here, Slip_ratio_zero is a rear wheel slip ratio zero adjustment value for compensation for a difference between the diameter of front wheels and that of rear wheels and the like, and is detected when the vehicle is started and stored in the ECU 11.

Detailed Description Text (173):
It is further understood by those skilled in the art that the foregoing is a preferred embodiment of the invention, and that various changes and modifications may be made without departing from the spirit and scope as thereof.

L3: Entry 1 of 1 File: USPT Mar 4, 2003

DOCUMENT-IDENTIFIER: US 6528959 B2
TITLE: Driving force control system for front-and-rear wheel drive vehicles

Detailed Description Text (18):
During the drive mode, the target driving force FCMD is calculated or determined by looking up a table an example of which is shown in FIG. 4, according to the detected vehicle speed Vcar and AP opening .theta.AP. In FIG. 4, there are shown typical table values obtained, respectively, when the AP opening .theta.AP is equal to 0 degrees, 5 degrees, and 80 degrees. The table is configured such that the target driving force FCMD becomes larger with an increase in the AP opening .theta.AP, and becomes smaller with an increase in the vehicle speed Vcar. It should be noted that a line designated by the AP opening .theta.AP of 0 degrees represents table values corresponding to the shift lever position of D4. In this case, the target driving force FCMD is calculated as a negative value.

Detailed Description Text (26):
If the answer to the question of the step S41 is affirmative (YES), i.e. if the control mode is the drive mode, at the following steps S43 to 46, parameters for setting the target front-rear wheel differential rotational speed DN_F_R between the front and rear wheels are determined by looking up respective tables. Among these parameters, a target slip ratio DRV_Slip_ratio is a basic value of the target front-rear wheel differential rotational speed DN_F_R, and the other parameters are correction coefficients for multiplying the target slip ratio DRV_Slip_ratio thereby.

Detailed Description Text (27):
First, at a step S43, the target slip ratio DRV_Slip.sub.13 ratio is looked up according to the slope angle SLOPE_ANG. FIG. 7 shows an example of a target slip ratio table, and the table is configured such that the target slip ratio DRV_Slip_ratio assumes a smaller value as the slope angle SLOPE_ANG is larger, when the slope angle SLOPE_ANG is within a range of 5 degrees to 25 degrees. This is because as the slope becomes steeper, a larger portion of the weight of the vehicle 2 is applied to the rear wheels WRL, WRR, to make the front wheels WFL, WFR prone to slip, and therefore, the target slip ratio DRV_Slip_ratio is set to a smaller value to thereby prevent slippage of the front wheels WFL, WFR, at an early stage, thereby making it easier for the vehicle 2 to climb up the slope.

Detailed Description Text (55):
The target front-wheel driving force FCMD_ENG calculated as described above is converted to an actuator output value DBW_TH dependent on the vehicle speed Vcar by looking up a DBW_TH table an example of which is shown in FIG. 14, at the step S26 in FIG. 2. The drive signal based on the actuator output value DBW_TH is delivered to the actuator 24 to control the throttle valve opening .theta.TH, whereby the driving force of the engine 3 is controlled.

Detailed Description Text (73):
From any of the steps S131, S141, and S142, the program proceeds to the step S143, wherein it is determined whether or not the downhill traveling flag F_RGNS1 assumes

1. If the answer to this question is affirmative (YES), i.e. if the vehicle is traveling downhill, the program proceeds to the step S144, wherein a steering wheel-dependent correction coefficient table an example of which is shown in FIG. 23 is looked up to retrieve a steering angle-dependent correction coefficient KSTR_Slip for calculation of the target deceleration DIC_G.

Detailed Description Text (88):
Then, the program proceeds to a step S208, wherein an increasing correction value table an example of which is shown in FIG. 24 is looked up to retrieve an increasing correction value ADD_DIC_G for the target deceleration DIC_G for the straightforward traveling of the vehicle 2. In FIG. 24, a curve indicated by the broken line represents table values of an increasing correction value ADD_DIC_G--BASE for the straightforward traveling and a curve indicated by the solid line represents table values of an increasing correction value ADD_DIC_G_BASE for turning, referred to hereinafter, both the values each being set to a negative value. Further, the increasing correction value table is configured such that the two increasing correction values ADD--DIC_G and ADD_DIC_G_BASE are larger (larger in absolute value) as the brake pressure PBR is higher, and at the same time, within a range of the brake pressure PBR equal to or lower than a predetermined brake pressure PBR1, the increasing correction value ADD_DIC_G for the straightforward traveling is larger (larger in absolute value) than the increasing correction value ADD_DIC_BASE for the turning. This is because when the brake pressure PBR is equal to or lower than the predetermined brake pressure PBR1, i.e. when the brake pedal is stepped on with a weak force, the vehicle 2 can be running on a low-friction road surface, and on such a low-friction road surface, only when the vehicle 2 is traveling straightforward in which the vehicle is more stabile than when the vehicle 2 is turning, the increasing correction value ADD_DIC_G for the straightforward traveling is used to set the target deceleration DIC_G to a larger value than when the vehicle 2 is turning, and otherwise i.e. when the vehicle 2 is turning, the increasing correction value ADD_DIC_G_BASE for the turning set by the ideal braking force distribution between the front and rear wheels is used to set the target deceleration speed DIC_G. Further, when the brake pressure PBR is equal to or larger than the predetermined brake pressure PBR1, the two increasing correction values ADD_DIC_G and ADD_DIC_G_BASE are set to an identical value. This is because when the brake pressure PBR is in such a large-value range, the driver is presumed to be demanding a large braking force, and to meet the demand, the target deceleration DIC_G is set to a large value.

Detailed Description Text (89):
Next, the program proceeds to a step S209, wherein similarly to the above, the increasing correction value table is looked up according to the brake pressure PBR to retrieve an increasing correction value ADD_DIC_BASE for the turning for correcting the target deceleration DIC_G.

Detailed Description Text (107):
Referring again to FIG. 17, after the deceleration substitution process executed at the step S150, the program proceeds to a step S151, wherein a deceleration-time remaining charge-dependent correction coefficient table an example of which is shown in FIG. 25 is looked up according to the remaining charge SOC (%), to determine a deceleration-time remaining charge-dependent correction coefficient KSOC_RGN. The deceleration-time remaining charge-dependent correction coefficient KSOC_RGN is used at a step S152 as a multiplication factor for multiplying the target deceleration DIC_G thereby.

Detailed Description Text (115):
Here, V_RGN_SLOPE1 represents a first predetermined vehicle speed which is lower than the second predetermined vehicle speed V_RGN_SLOPE2 and assumes a value (e.g. 1 km/h) which is very close to 0 indicative of stoppage of the vehicle 2, and in the equation (14), the engine braking force FENG_OFF is determined by looking up an engine braking force table an example of which is shown in FIG. 26 according to the

vehicle speed Vcar. In this step S158, as the vehicle speed Vcar, the second predetermined vehicle speed V_RGN_SLOPE 2 is used.

Detailed Description Text (141):
Further, the engine braking force applied when the AP 17 is in the released state may be determined not only by the method of looking up the table according to the vehicle speed Vcar as in the present embodiment described above, but also by a method based on the gear ratio and the vehicle speed Vcar (or average rear-wheel speed V_RR), or the shift position and the vehicle speed Vcar (or average rear-wheel speed V_RR).

Previous Doc Next Doc Go to Doc#

L4: Entry 1 of 1 File: USPT Mar 4, 2003

DOCUMENT-IDENTIFIER: US 6528959 B2
TITLE: Driving force control system for front-and-rear wheel drive vehicles

Detailed Description Text (8):
The engine 3 has a crankshaft, not shown, to which is mounted a crank angle position sensor 13 which delivers to the ECU 11 a crank pulse signal CRK whenever the crankshaft rotates through a predetermined angle. Further, mounted to a mainshaft 5b of an automatic transmission 5 and a countershaft, not shown, of the same are a mainshaft rotational speed sensor 14a of a magnetic pickup type and a countershaft rotational speed sensor 14b of the same type, respectively. The two sensors 14a, 14b also output to the ECU 11 respective pulse signals indicative of a sensed rotational speed Nm of the mainshaft 5b and a rotational speed Ncounter of the countershaft. The ECU 11 calculates an engine rotational speed NE based on the crank pulse signal CRK, and then calculates a speed ratio ETR of a torque converter 5a from the engine rotational speed NE and the mainshaft rotational speed Nm (ETR=Nm/NE). Further, a motor rotational speed sensor 15 formed by a resolver is mounted to the motor 4 to output a pulse signal indicative of a sensed rotational speed Nmot of the motor 4. This signal is also delivered to the ECU 11.

Detailed Description Text (9):
Further, the ECU 11 receives a signal indicative of a sensed degree of opening (accelerator pedal opening) .theta.AP including ON/OFF (stepped-on/released) states of the accelerator pedal 17 from an accelerator pedal opening sensor 16, and a signal indicative of a remaining charge SOC stored in the battery 7 from a charge amount sensor 18. Still further, the ECU 11 is supplied with a signal indicative of a sensed braking pressure PBR from a braking pressure sensor 19 mounted to a master cylinder of a brake 30, a signal indicative of a sensed steering angle .theta.STR of a steering wheel 31 from a steering angle sensor 20, a signal indicative of a sensed shift lever position POSI of the automatic transmission 5 from a shift position sensor 21, and signals indicative of sensed accelerations GF, GR of the respective front and rear wheels WF, WR from acceleration sensors 22, 23.

Detailed Description Text (141):
Further, the engine braking force applied when the AP 17 is in the released state may be determined not only by the method of looking up the table according to the vehicle speed Vcar as in the present embodiment described above, but also by a method based on the gear ratio and the vehicle speed Vcar (or average rear-wheel speed V_RR), or the shift position and the vehicle speed Vcar (or average rear-wheel speed V_RR).